LOW COST AUTOMATIC WATER LEVEL CONTROL FOR DOMESTIC APPLICATIONS

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LOW COST AUTOMATIC WATER LEVEL CONTROL FOR DOMESTIC APPLICATIONS

A Thesis submitted in partial fulfillment of the requirements for the degree of

Bachelor of Technology in "Electrical Engineering"

By

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CERTIFICATE

This is to certify that the thesis entitled "**Low Cost Water Level Control for Domestic Applications**", submitted by **Ishwar Chandra Murmu (Roll. No. 109EE0288)** and **Laloo Kumar Yadav (Roll. No. 109EE0620)** is in partial fulfilment of the requirements for the award of **Bachelor of Technology** in **Electrical Engineering** during session 2010-2011 at National Institute of Technology, Rourkela. A bonafide record of research work was carried out by them under my supervision and guidance.

The candidates have satisfied all the prescribed requirements.

The Thesis which is based on candidates' self work, have not submitted elsewhere for a degree/diploma.

In my opinion, the thesis is of standard required for the award of a bachelor of technology degree in Electrical Engineering.

Place: Rourkela

Dept. of Electrical Engineering
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Assistant Professor

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Ishwar Chandra Murmu

Laloo Kumar Yadav

B.Tech (Electrical Engineering)

Dedicated to

Our Parents

ABSTRACT

The drinking water crisis in India is reaching alarming proportions. It might very soon attain the nature of global crisis. Hence, it is of utmost importance to preserve water. In many houses there is unnecessary wastage of water due to overflow in Overhead Tanks. Automatic Water Level Controller can provide a solution to this problem. The operation of water level controller works upon the fact that water conducts electricity. So water can be used to open or close a circuit. As the water level rises or falls, different circuits in the controller send different signals. These signals are used to switch ON or switch OFF the motor pump as per our requirements.

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ABBREVIATIONS AND ACRONYMS

UGT	-	Under Ground Tank
OHT	-	Overhead Tank
IC	-	Integrated Circuit
BJT	-	Bi-polar Junction Transistor
SPDT	-	Single Pole Double Throw
NO	-	Normally Open
NC	-	Normally Closed
COM	-	Common
LED	-	Light Emitting Diode

CHAPTER **1**

Introduction

1.1 MOTIVATION:

The total amount of water available on Earth has been estimated at 1.4 billion cubic kilometers, enough to cover the planet with a layer of about 3 km. About 95% of the Earth's water is in the oceans, which is unfit for human consumption. About 4% is locked in the polar ice caps, and the rest 1% constitutes all fresh water found in rivers, streams and lakes which is suitable for our consumption. A study estimated that a person in India consumes an average of 135 litres per day.This consumption would rise by 40% by the year 2025. This signifies the need to preserve our fresh water resources. [1]

1.2 THESIS OBJECTIVES:

The following objectives are likely to be focused and achieved at the end of the project.

1) To create the most cost-effective and reliable water level controller using as less resources as possible.
2) To study the controller model and observe its characteristics.
3) To compare the controller with the conventional controllers available in market and find the advantages of the former over the latter.
4) To suggest any ideas or improvements that can lead to future development of the controller.

1.3 ORGANISATION OF THESIS:

The thesis is organised into six chapters including the chapter of introduction. Each chapter is different from the other and is described along with the necessary theory required to comprehend it.

Chapter2 deals with the water level controller components. The circuit diagram gives an overview of the whole system. Then, each of the components is studied individually. Their purpose in the system is explained along with their ratings and connections.

Chapter3 describes the basic operation of the controller. A step-by-step analysis is presented on the actions that would take in the controller beginning from the detection of water by the metallic contacts to the switching ON or switching OFF of the pump accordingly. We then study the truth table of the water level controller. It summarizes the logic involved in the complete operation of the controller. The scenarios occurring in the controller i.e. water being filled to the top of the OHT and then being emptied are represented diagrammatically. Adjacently, the change in states occurring in the different circuit elements is depicted. Then we have a comparative study of the water level controller with commercially available controllers. The advantages and approximate cost of the whole apparatus were discussed.

Chapter4 concludes the work performed so far. The possible limitations in proceeding research towards this work are discussed. The future work that can be done in improving the current scenario is mentioned. The future potential along the lines of this work is also discussed.

CHAPTER **2**

System Components

2.1 INTRODUCTION:

The water level controller we propose to make in our project depends on two detection points in the OHT. The water level must be controlled at these two points. To facilitate this, we use sensors. In our case, these sensors are metallic contacts with space between them present at each detection point. When water reaches a sensor, a proper circuit must be present such that the presence of water is detected and a signal is produced. This signal must pass through logic circuits to give the correct actuator output. Also it must be strong enough to activate the actuator. A similar action must take place when water reaches another sensor. Our circuit essentially uses the high and low states of a NAND gate to activate or deactivate the actuator. Simply put, we rely on the ON and OFF states of the actuator.

2.2 COMPONENTS USED:

The Water Level Controller has the following main components:-

- Metallic Contacts
- Transformer
- Full-wave rectifier
- Voltage Regulator IC
- Centrifugal Submersible Pump
- Relay
- NAND gate
- 555 Timer IC
- Transistor
- Light Emitting Diode
- Voltage Divider Circuit

2.2.1 *Metallic Contacts*

These are L-shaped aluminium contacts which conduct electricity when the space between them is bridged by water. For our project, we have used L-shaped brackets. Two contacts at the bottom part of the tank form the indicator for low level of water. Similarly two contacts at the upper part of the tank indicate that water is about to overflow.

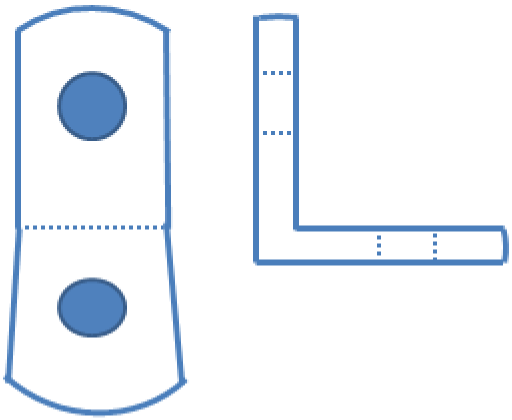


FIGURE 2.1: L-SHAPED METALLIC CONTACTS

2.2.2 *Transformer*

A centre-tapped step-down transformer is used to provide a suitable voltage to the full-wave rectifier. We specifically selected this transformer so that the device could be connected directly to the wall outlet. Also the centre tapping helps us to generate a positive polarity voltage required for the circuit. Rating: 230/15 V AC, 50 Hz

FIGURE 2.2: CENTRE-TAP STEP DOWN TRANSFORMER

2.2.3 Full-Wave Rectifier

The full wave rectifier consists of four 1N4007 diodes and two 1000µF capacitors. It is used to convert the AC supply of the wall outlet to DC supply which will run majority of the circuit elements.

It converts an a.c. voltage into a pulsating dc voltage using both half cycles of the applied ac voltage. For this purpose, it uses two diodes of which one conducts during one half cycle while the other conducts during the other half cycle of the applied ac voltage.

During the positive half cycle of the input voltage, the diode D2 becomes forward biased and D4 becomes reverse biased. Hence D2 conducts and D4 remains OFF. The load current flows through D2 and the voltage drop across the load will be equal to the input voltage. Now during the negative half cycle of the input voltage, diode D2 becomes reverse biased and D4 becomes forward biased. Hence D2 remains OFF and D4 conducts. The load current flows through D4 and the voltage drop across the load will be equal to the input voltage.

2.2.4 Voltage Regulator IC

Connected to the rectifier outputs are voltage regulators IC 7805, IC 7809 and IC 7812 in parallel. The output of IC 7805 provides Vcc to the NAND gate and is also used to supply the DC voltage to support current flow between the metallic contacts. IC 7809 provides Vcc for the BJT to run the relay. The output of IC 7812 is used to give Vcc to 555 Timer IC.

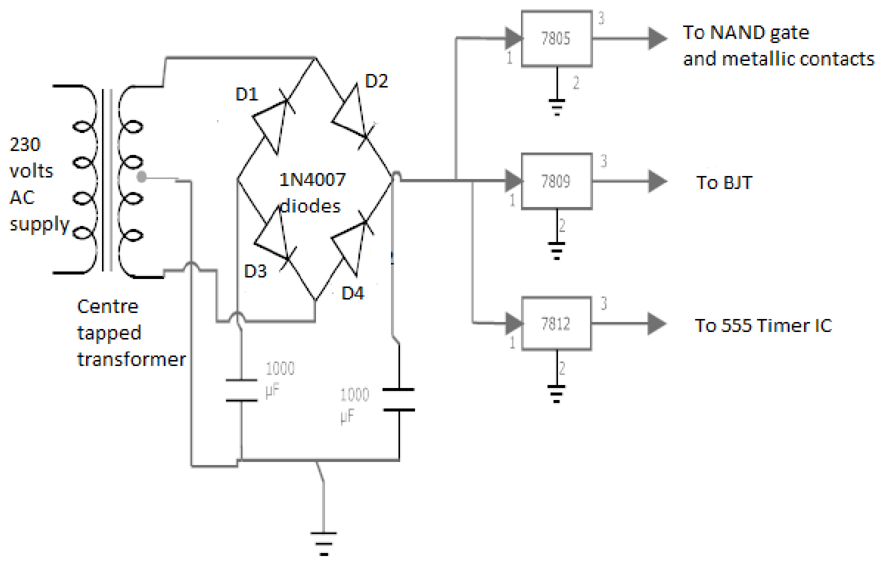


FIGURE 2.3: FULL WAVE RECTIFIER WITH VOLTAGE REGULATORS

2.2.5 Centrifugal Submersible Pump

The centrifugal pump is commonly found inside a submersible fountain pump and some air conditioning units. As the impeller inside it turns, water is drawn in one side of the pump. It is then expelled out the other end. The power and size of the impeller decide the amount of water flow. More water can be pumped if we have a larger impeller. As the impeller rotates, it moves water from the inlet (which is located near the center of rotation of the impeller) along the surfaces of the impeller to the outer portions of the volute by means of centrifugal force (thus, its name centrifugal pump). As this water collects in the outer regions of the volute, it is directed to the outlet. The water leaving the outlet causes the water pressure to drop at the inlet. To match the rate with which water is leaving the outlet, the pump sucks in new water at the inlet. These pumps must be primed before starting, which in this case is already done because of its underwater application. Rating: Voltage: 165-240V/ 50 Hz; Power: 18W; Output: 1200L/hr. [2]

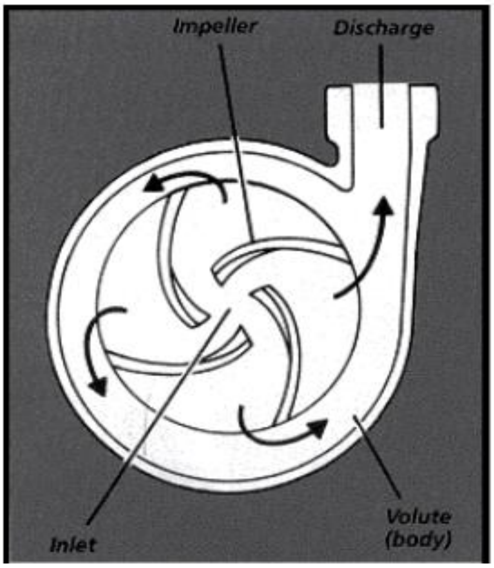


FIGURE 2.4: CENTRIFUGAL SUBMERSIBLE PUMP

2.2.6 Relay

Relays are defined as remote controlled electrical switches that are controlled by another switch e.g. - a horn switch. Relays allow a small current flow in a circuit to control a higher current circuit. The relay used here is a Single Pole Double Throw (SPDT) relay whose magnetizing coil terminals operate on 6V DC supply. It has the following terminals:

COIL- This is one end of the coil.

COIL- This is the other end of the coil. These are the terminals where we apply voltage to in order to give power to the coils (which then will close the switch). The polarity does not matter. One side gets positive voltage and the other side gets negative voltage.

NO- This is Normally Open switch. This is the terminal where the device is connected that we want the relay to activate when the relay is powered. The device connected to NO terminal will be deactivated when the relay has no power and will turn on when the relay receives power. We will use this terminal for powering the pump.

NC- This is the Normally Closed Switch. This is the terminal where we connect the device that we want powered when the relay receives no power. The device connected to NC will be active when the relay has no power and will deactivate when the relay receives power.

COM- This is the common terminal of the relay. When the relay is powered and the switch is closed, COM and NO will be shorted. If the relay isn't powered and the switch is open, COM and NC get shorted.

It is used in normally open mode. A 1N4007 diode and a 100µF capacitor are connected in parallel to the magnetizing coil terminals. This is done because when voltage input to the relay coil is removed and its magnetic field collapses, a huge reverse voltage is produced. Without proper protection, this voltage will cause the contact that is switching the relay coil to arc and will in time destroy it. [3]

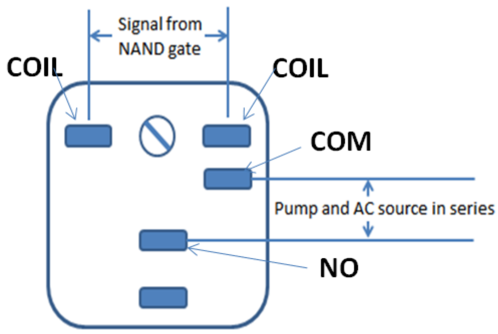


FIGURE 2.5: RELAY TERMINAL LAYOUT

2.2.7 NAND Gate

A NAND gate (Negated AND or NOT AND) is a logic gate which produces an output that is false only if all its inputs are true. A LOW (0) output results only if both the inputs to the gate are HIGH (1); if one or both inputs are LOW (0), a HIGH (1) output results. If water falls below the bottom contacts, the pump must switch on. If water fills above the upper contacts, the pump must switch off. This operation is obtained by HD74LS00P NAND Gate. Let the signal from top and bottom contacts be Signal A and Signal B respectively. [4]

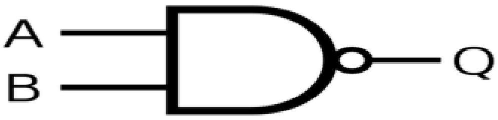


FIGURE2.6: NAND GATE

TABLE 2.1: TRUTH TABLE OF NAND GATE

Input A	Input B	Output Q
0	0	1
0	1	1
1	0	1
1	1	0

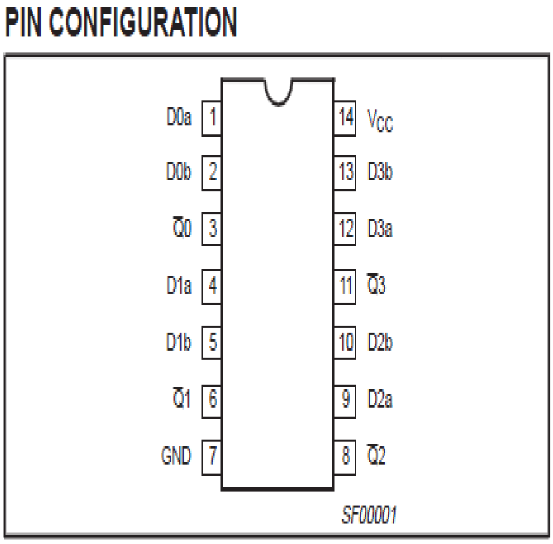


FIGURE 2.7: PIN CONFIGURATION OF 74F00 QUAD 2-INPUT NAND GATE

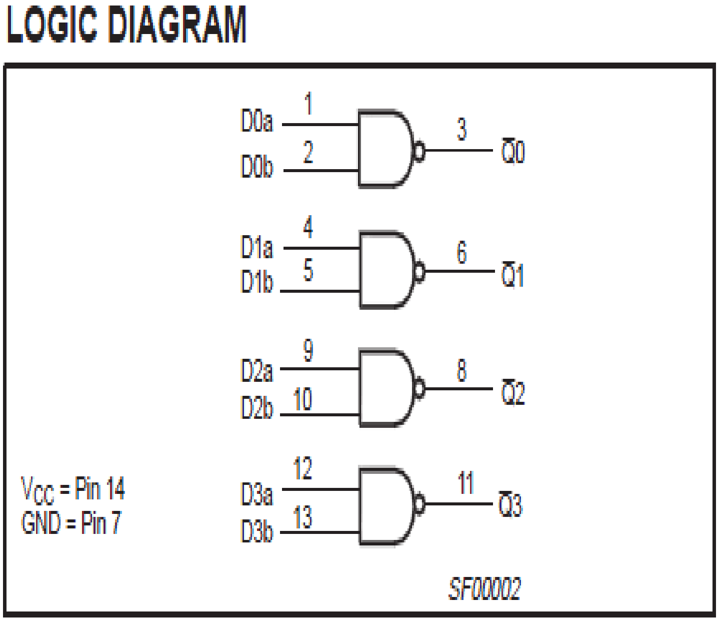


FIGURE 2.8: LOGIC DIAGRAM OF 74F00 QUAD 2-INPUT NAND GATE

2.2.8 555 Timer IC

Here, we use the 555 timer as a flip-flop element i.e. in bi-stable mode.

- Bi-stable mode

In bi-stable mode, the timer has two stable states, high and low. By making the Trigger input low the output of the circuit goes into the high state. By making the Reset input low we cause the output to go into the low state. Using this mode avoids unnecessary switching of relay. [5]

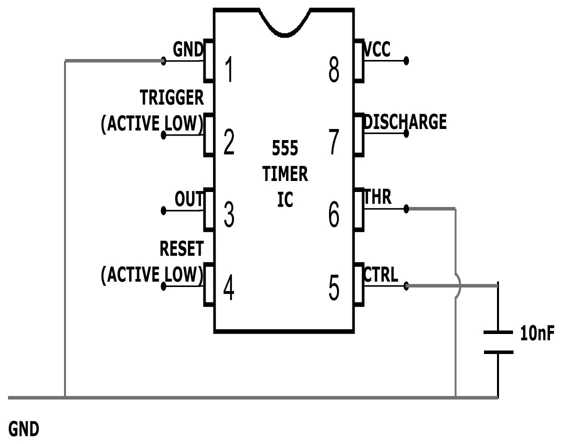


FIGURE 2.9: 555 TIMER IN BI-STABLE MODE

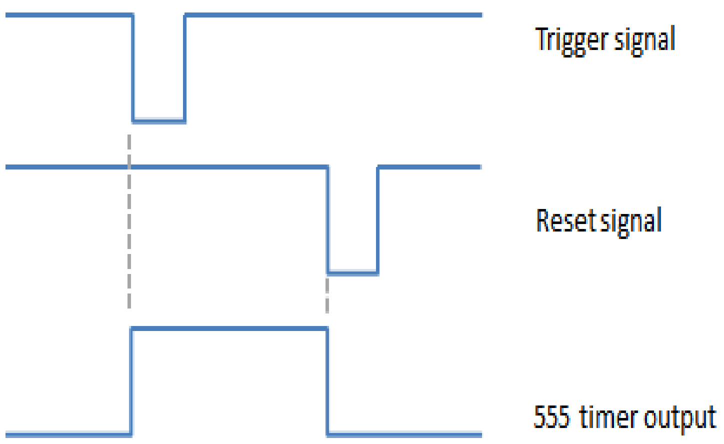


FIGURE 2.10: 555 TIMER WAVEFORMS

2.2.9 Transistor

Transistors are semiconductor devices used to amplify and switch electronic signals and electrical power. At least three terminals for connection to external circuit are present. By applying voltage or current to one pair of the transistor the current through other pair of terminal changes. Because the controlled (output) power can be higher than the controlling (input) power, transistors can amplify a signal. In our circuit, the output from the NOT gate is not strong enough to activate the relay. Hence, we used transistor C547B to amplify it. IC 7809 provided the 9 volts Vcc to the BJT which was connected in common base configuration.

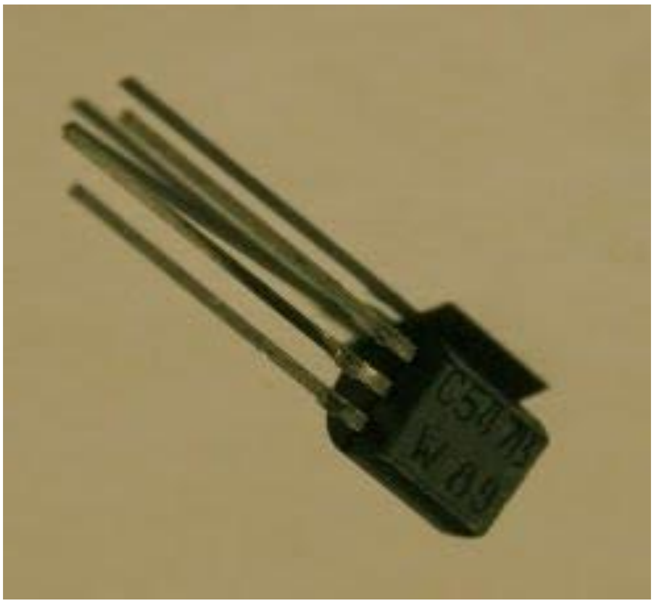


FIGURE 2.11: A C547 TRANSISTOR

A diode and a capacitor are connected in parallel to the magnetizing coil terminals of the relay. This is done because when the voltage input to the relay coil is removed and its magnetic field collapses, a huge reverse voltage is produced. Without proper protection, this voltage will cause the contact which is switching the relay coil to arc and in time will destroy it.

2.2.10 Light Emitting Diode

Three LEDs are used to indicate-

- The high state of 555 timer IC.
- The low state of 555 timer IC.
- The ON/OFF state of the pump.

A resistance of 1 KΩ should be connected in series with the LED to protect it from high voltages.

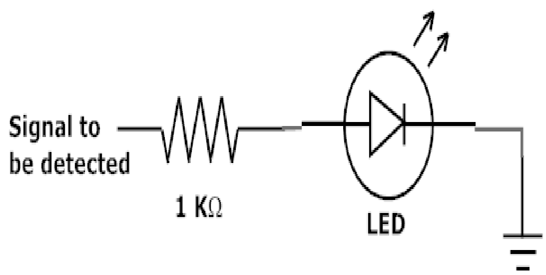


FIGURE 2.12: LIGHT EMITTING DIODE

2.2.11 Voltage Divider Circuit

We use a voltage divider circuit across the metallic contacts to get input signals. So when the circuit is open, we get 5 V. On the other hand, we get 0 V when the circuit is closed. Assuming Boolean logic, the presence of water between contacts was represented by 0 and its absence by 1.

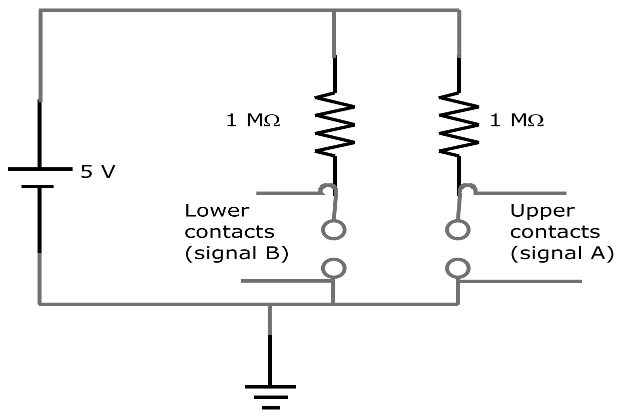


FIGURE 2.13: VOLTAGE DIVIDER CIRCUIT

2.3 CIRCUIT DIAGRAM:

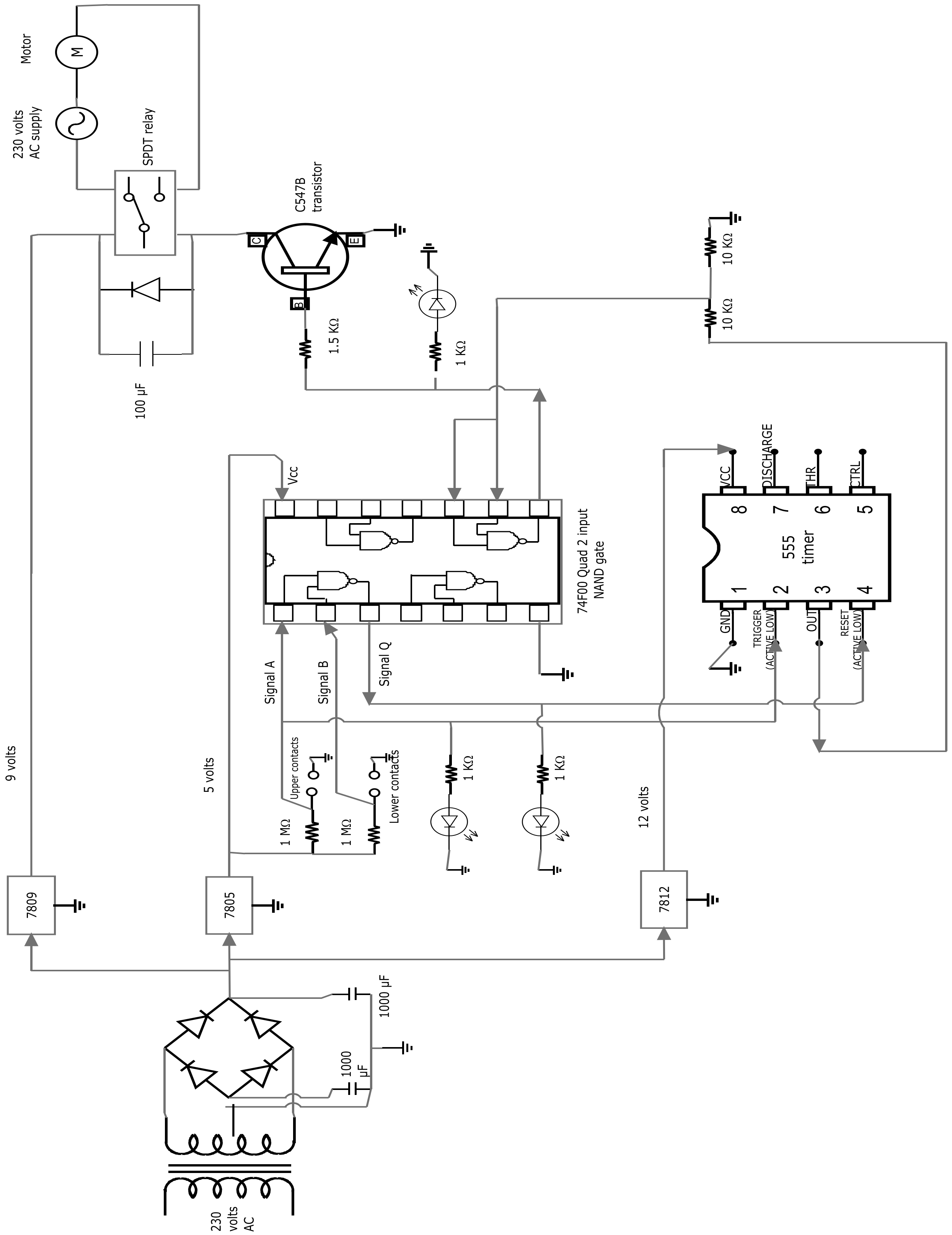
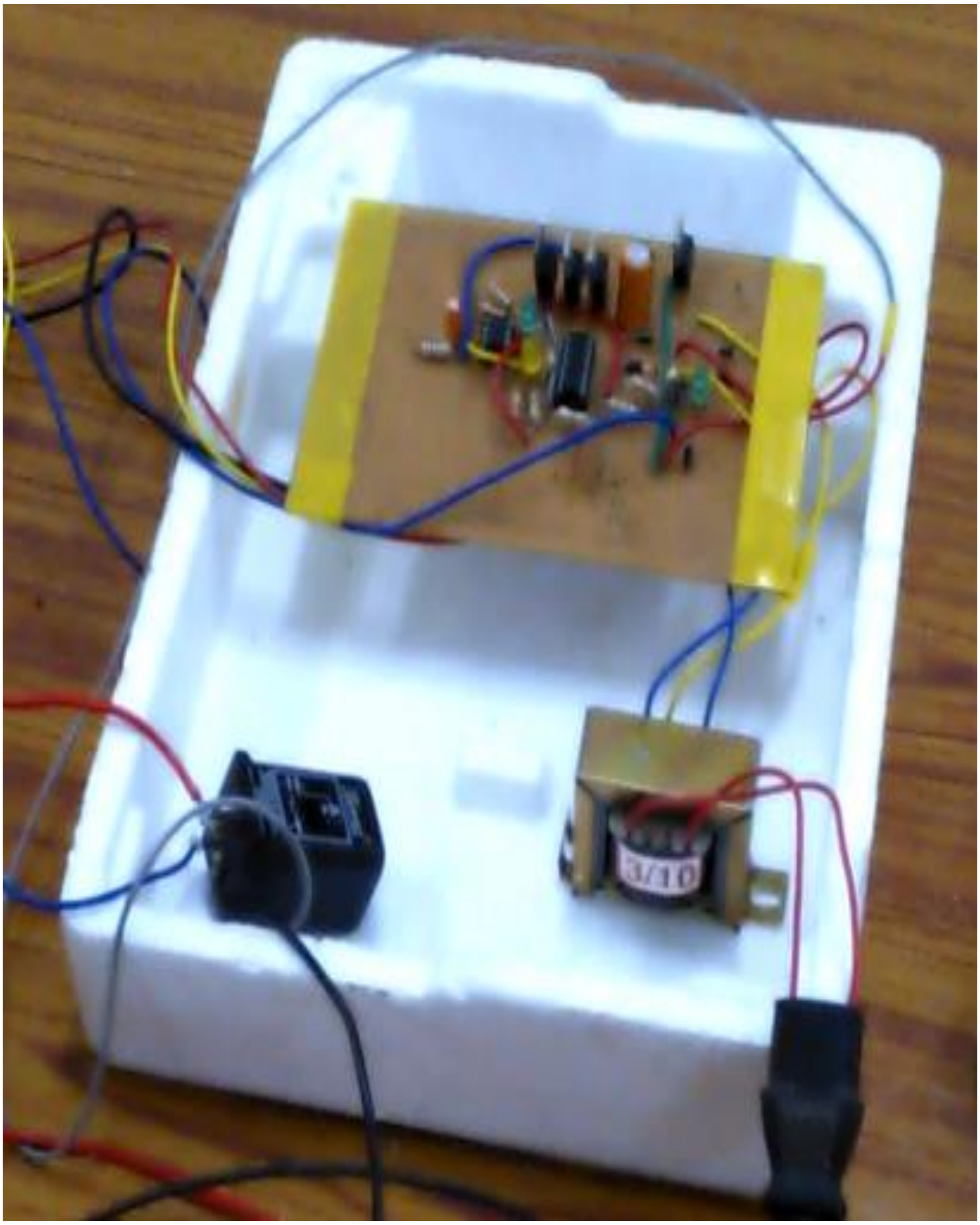


FIGURE 2.14: SCHEMATIC DIAGRAM OF WATER LEVEL CONTROLLER

2.4 CIRCUIT LAYOUT:



2.5 COMPLETE HARDWARE SETUP:

2.6 CONCLUSION:

Thus we have assembled a circuit which works on the conduction of electricity by water. This circuit works using logic gates and the output obtained is in the form of ON and OFF state of the centrifugal submersible pump.

CHAPTER **3**

Logic and Operation

3.1 INTRODUCTION:

After assembling the system, what remains is to observe its operation and efficiency. This can be done by breaking down the activity of the controller from the detection of water to the working of the pump. We go over the responses obtained when water reaches the sensors and the logic employed behind it. We also try to justify how a system as simple as ours can compete with those available commercially.

3.2 STEP-BY-STEP OPERATION:

- We placed metallic contacts both at the lower and upper area of the OHT. When water filled the gap between them, the adjoining circuit closed and a signal (current) flowed.

- These signals were given to a NAND gate which produced an output signal Q.

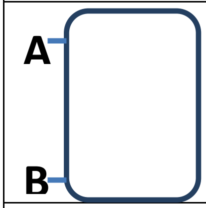
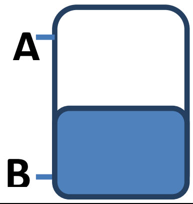
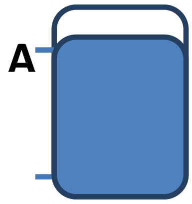
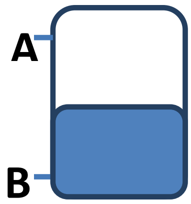
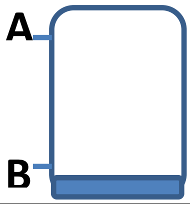
- This signal Q was used to provide Reset signal to the 555 timer IC. Also signal A was fed as the Trigger input to the 555 timer IC.

- The output of the timer was passed through a NOT gate to get the desired signal for controlling the pump.

- The NOT output signal was then passed through a BJT to amplify it and make it strong enough to activate the relay.

- The pump was started through the relay and water was provided to the OHT.

TABLE 3.1: TRUTH TABLE OF WATER LEVEL CONTROLLER

Water Level	Input Signal A	Input Signal B	NAND Output	555 timer output	NOT gate output	Pump State
	1	1	0	0	1	1
	1	0	1	0	1	1
	0	0	1	1	0	0
	1	0	1	1	0	0
	1	1	0	0	1	1

3.3: Advantages of the proposed water level controller

A. Maintenance

It is an economical system that requires very less maintenance as compared to conventional system as it has no complicated circuits and delicate mechanisms. This saves the additional maintenance cost.

B. Cost

The main advantage of the water level controller is it has very low cost than the conventional one available in markets. For example, some commercial controllers use microcontrollers which alone costs around Rs.800. Some controllers even have a price range of Rs.2000-Rs. 4000. But for our system, the components used are less in number and easily available. Hence losses will be less leading to a better efficiency.

C. Construction

The construction of a water level controller is very simple as it requires only a few components. The circuit involved is also relatively simpler.

D. Skill Required

Since the system of water level controller is simpler than the ones conventionally available, it can be easily made at home. The controller can also be easily operated by anyone.

On a final note, the conventional controllers in market mostly use capacitive sensors and microcontrollers. These increase the cost as well as the complexity of the system. We have developed a rather simpler but efficient model of a water level controller.

3.4 COST ESTIMATION OF WATER LEVEL CONTROLLER:

TABLE 2: COST ESTIMATION

Sr. no.	**Particulars**	**Cost in INR (approx.)**
1	Metallic Contacts	20
2	Transformer	40
3	Full-wave Rectifier	30
4	Voltage Regulator IC	20
5	Centrifugal Submersible Pump	150
6	Relay	30
7	NAND Gate	5
8	555Timer IC	10
9	Transistor	5
10	Light Emitting Diode	10
11	Voltage Divider Circuit	20
12	Miscellaneous	100
	TOTAL	440

Centrifugal submersible pump and relay are the auxiliary components of the system. They are not considered as a part of the control circuit. Their cost and ratings of the pump vary according to load connected to the system. An increase in load will lead to selection of a larger pump. Likewise, the current flowing through the circuit will also increase. Therefore, we would require a higher rated relay. For our project, we had to pump a small volume of water for demonstration purpose so we used a low rated pump.

CHAPTER **4**

Conclusion and Future Works

4.1 RESULTS:

The experimental model was made according to the circuit diagram and the results were as expected. The motor pump switched ON when the OHT was about to go dry and switched OFF when the OHT was about to overflow.

4.2 CONCLUSION:

- This system is very beneficial in rural as well as urban areas.
- It helps in the efficient utilization of available water sources.
- If used on a large scale, it can provide a major contribution in the conservation of water for us and the future generations.

In these days, when Earth's reserve of consumable water is decreasing every moment, every drop has its value. Water level controller is a simple yet effective way to prevent wastage of water. Its simplicity in design and low cost components make it an ideal piece of technology for the common man.

4.3 FUTURE WORK:

The water level controller designed in this project can be used to control water flow. However, there is no way of knowing whether the source of water, which in this case is the UGT, actually has water or not. If no water source is present, then the submersible pump would start running unnecessarily and overheat itself. This could be taken care by implementing another sensor. Also, the rate of water input must always be equal to or greater than the rate of water output. To make this happen we could use a speed regulator. If these issues are taken care of then a more efficient and reliable performance can be achieved.

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